Snowdonia Aerospace Airspace Change Proposal
Full Options Appraisal – Phase II (Stage 3A), ACP-2019-58
Llanbedr Danger Area (DA)

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Executive Summary

This report documents the Options Appraisal (Phase II - Full) as part of the "Stage 3A Consultation Preparation" element of the Snowdonia Aerospace LLP submission for an Airspace Change Proposal, Reference: ACP-2019-58, Llanbedr Danger Area (DA), under the Civil Aviation Authority (CAA) CAP1616 Airspace Change Process.

Snowdonia Aerospace LLP is continuing to progress and further develop a number of complementary business opportunities at Llanbedr Aerodrome relating to aerospace Research, Development, Test and Evaluation (RDT&E) and military aircraft training. To support these operations (and others) action is required to upgrade and formalise the current airspace around the Aerodrome as the present provision is insufficient to meet the identified future need and risks restricting opportunities that are in the strategic economic interest of the UK and Welsh governments and required to sustain long term employment in the region. Snowdonia Aerospace LLP (hereafter also referred to as the Change Sponsor) is therefore developing two Airspace Change Proposals (ACPs) to underpin these activities:

- ACP-2019-58, Llanbedr Danger Area (DA), which can be accessed online via: https://airspacechange.caa.co.uk/PublicProposalArea?pID=193
- ACP-2020-02, Llanbedr Aerodrome Traffic Zone (ATZ), which can be accessed online via: https://airspacechange.caa.co.uk/PublicProposalArea?pID=211

The two Proposals are independent of each other and are being progressed separately.

The ACP-2020-02, which is specific to supporting ongoing and future military aircraft training, has presently been Paused and is NOT part of this forthcoming consultation. An opportunity to participate in the ongoing consultation of this ACP will follow at some stage in the future.

The forthcoming consultation and the basis of this document is specific to ACP-2019-58, which is solely in support of the RDT&E opportunities (and not related to military aircraft training), with a view to creating a permanent Danger Area that will enable Llanbedr Aerodrome to increase support to the RDT&E for next-generation UK aerospace - *e.g.* drones (particularly non-military "drones for good"), electric aircraft, urban/regional air mobility vehicles, balloons, airships, near-space testing *etc*.

The CAA Civil Aviation Publication CAP1616 defines a six-stage process through to implementation of a permanent airspace change, some of which have more than one step. Snowdonia Aerospace has successfully completed Stage 1 (Define) and Stage 2 (Develop and Assess) and all the supporting documentation can be found on the CAA Airspace Change Portal via the link above. At this point the CAA also determined that ACP-2019-58 was confirmed as a Level 1 change. The requirements for Stage 3A, Consultation Preparation, are as follows:

1. produce a draft Consultation Strategy detailing the scale, nature and timescales of the proposed consultation;
2. produce a draft Consultation Document that allows stakeholders – including those with no technical expertise – to understand the potential impact of the proposed changes;
3. produce an Options Appraisal (Phase II – Full) identifying potential impacts and mapping potentially affected stakeholders.

This document addresses the requirement for (3), the Options Appraisal, and the following conclusions have been drawn from the analysis:

1. The established use for the Llanbedr site is as an operational airfield and its recognised historic and current / ongoing uses. The site has an existing Certificate of Lawfulness (Ref: NP5/62/LU372) for research and development for testing, evaluation and development of drones and has a current planning consent for a mixed use incorporation, both its established use and for aircraft maintenance, including decommissioning and disassembly, parts recovery, refitting and engineering training (Ref: NP5/62/372A);

2. Snowdonia Aerospace has constructed a model for anticipated Danger Area (DA) utilisation. The number of novel aerospace system flight movements is expected to double, but the numbers are relatively small (~100 days of Danger Area activation per annum and <200 flights per annum), the vast majority of operations (~90%) will be over the aerodrome or out over the sea and the vehicle size (the majority <150kg) and propulsion type (50%+ electric) are also mitigating factors;
3. Using the utilisation model, Snowdonia Aerospace has also assessed the impacts of the permanent DA Design Options #1 and #2 proposed at Stage 2A against a "do nothing" option (continuing under a Temporary Danger Area) using six key environmental criteria in a methodology agreed with the CAA to reflect the unique nature of the RDT&E activities at Llanbedr;
4. The noise profile for an estimated 66% of the novel aerospace systems that will operate at Llanbedr will be below the ambient daytime baseline experienced by local residents and effectively inaudible beyond the airfield boundary. For the remaining 33%, representing about 30 days of operation per year, it is unlikely that noise profiles will be noticeably different from any other conventional fixed-wing general aviation or helicopters that use the airfield. The Airspace Change is therefore anticipated to have a negligible impact on perceived noise;
5. We estimate that only 10% of flight trials cases (roughly 10 days per year) will need to be conducted over land (*i.e.* east of the railway line). The flight tracks will be crafted to avoid overflight of buildings, property and any other sensitive areas and will also be appropriately geo-fenced. The Airspace Change is therefore anticipated to have a negligible impact on perceived overflight;
6. The annual fuel burn and CO2 emissions associated with flying activities at Llanbedr as a result of the airspace change will be less than that generated by a single passenger car that travels 10,000 miles a year at 35 miles per gallon. The Airspace Change is therefore anticipated to have a negligible impact on CO2 emissions;
7. Assessment of local air quality impacts are only required when the proposal affects an area in the vicinity of a location that has been designated as an air quality management area, which is not the case for Llanbedr. Details on the local approach to air quality can be found on the Gwynedd Council website and monthly data can also be accessed via the Welsh Air Quality Forum website;
8. We're confident that the evidence presented with regard to noise and overflight, together with the estimates for limited over land operation, will ensure the continued tranquillity of the local environment, but we will continue to engage with stakeholders on a regular basis;
9. The Airspace Change proposal is anticipated to have a negligible impact on biodiversity because it does not involve change in ground-based infrastructure.
10. Despite a predicted increase in both novel aerospace RDT&E flying and RAF/MOD training, there is still considered to be sufficient capacity to accommodate all activities safely and the Change Sponsor is committed to implementing Flexible Use of Airspace and Strategic Airspace Management principles;
11. The economic model for Llanbedr Aerodrome does not conform to that for a conventional airport, but a recent economic impact assessment suggested a multi-use aerospace site at Llanbedr (with aerodrome licencing, ATZ and DA implementation as fundamental building blocks) could contribute 515 jobs and £19.5m/annum of GVA at the local level and 765 jobs and £34m/annum of additional GVA in Wales over the next 10 years.

The analysis presented here will be taken forward into the public consultation at Stage 3C of the CAP1616 process and will be available for stakeholder review and comment.

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1. Introduction

1.1. Background

Llanbedr Aerodrome (EGFD), Gwynedd (Figures 1a-1d), is sited on a coastal promontory at the northerly end of Cardigan Bay[1] with bi-directional over-water approaches to the 2000m+ main runway (17/35), which is at an elevation of 8m above mean sea level. There are two additional cross runways 05/23 and 15/33. Under upcoming aerodrome licensing proposals it is currently intended the runways will be 2,188m, 1,199 and 799m respectively. The local geography is predominantly coastal lowland and farmland within Snowdonia National Park that is bounded to the east by the Rhinog mountains, which rise to 756m at a distance of 9500m (approx.) from the main runway. The village of Llanbedr (population 645, 2011 census) is 2000m (approx.) to the north-east of the northern threshold and there's also a transitory population during summer months at the Shell Island campsite (approx. 1000m to the north-west of the main runway northern threshold) and the Dyffryn caravan park (approx. 500m to the south of the main runway southern threshold). The overall population density is consistent with that for Gwynedd as a whole - *i.e.* <50 people per square km[2,3].

Fig. 1a *- aerial view looking west*

Fig. 1b *- aerial view looking east*

Fig. 1c *- aerial view looking north*

Fig. 1d *- aerial view looking south*

Llanbedr Airfield has a long history and established use for the research, development, test and evaluation (RDT&E) flying activities, particularly associated with the use of target drones, and also as a secondary/tertiary operating site for RAF Valley (EGOV, approx. 58km north/north-west). An Aerodrome Traffic Zone (ATZ)[4] and the original Danger Area D202 supported these activities prior to QinetiQ/MOD vacating the site in 2004, along with extant Danger Area D201, the closest edge of which is 25km (approx.) south-west of Llanbedr[5].

[1] View on Google Maps
[2] Ref: National Statistics Wales, June 2018
[3] Ref: Annual Lower Super Output Area (LSOA) Population Estimates, 2018
[4] Aerodrome Traffic Zone (ATZ) as detailed in Article 5 of the Air Navigation Order, 2016, Ref: Air Navigation Order, 2016
[5] Ref: https://www.aurora.nats.co.uk/htmlAIP/Publications/2018-08-02/html/eAIC/EG-eAIC-2018-087-Y-en-GB.html

The airfield currently supports an increasing mix of small (<20kg) and light (<150kg) drone RDT&E and General Aviation (GA) operations together with visiting military aircraft (fixed wing and rotary) and others including the search and rescue (SAR) helicopter from Caernarfon (EGCK, approx. 35km north/north-west), Police helicopter and Air Ambulance. The airspace is currently Class G. A local Flight Information Service (FIS) has been provided to support day-to-day operations and a Temporary Danger Area (TDA) has previously been consulted on and implemented as and when required, either as a whole or in part, to support RDT&E activities and provide a safe corridor to D201. There are GA aircraft operations most flyable days with an average of 100 to 200 movements per month. The airfield has also been designated as one of the candidate sites for a UK Spaceport by the Department for Transport (DFT) and Snowdonia Aerospace LLP has recently received a grant award from the UK Space Agency to generate a Horizontal Spaceport Development Master Plan.

1.2. Opportunity to be addressed and Statement of Need

Snowdonia Aerospace LLP is continuing to progress and further develop a number of complementary business opportunities at Llanbedr Aerodrome relating to aerospace RDT&E and military aircraft training. To support these operations (and others) action is required to upgrade and formalise the current airspace around the Aerodrome as the present provision is insufficient to meet the identified future need and risks restricting opportunities that are in the strategic economic interest of the UK and Welsh governments and required to sustain long term employment in the region. Snowdonia Aerospace LLP (hereafter also referred to as the Change Sponsor) is therefore developing two Airspace Change Proposals (ACPs) to underpin these activities:

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The two Proposals are independent of each other and are being progressed separately. The ACP-2020-02, which is specific to supporting ongoing and future military aircraft training, has presently been Paused and is NOT part of this forthcoming consultation. An opportunity to participate in the ongoing consultation of this ACP will follow at some stage in the future. The forthcoming consultation and the basis of this document and the Strategy now being proposed is specific to the ACP-2019-58 which is solely in support of the RDT&E opportunities (and not related to military aircraft training), with a view to creating a permanent Danger Area that will enable Llanbedr Aerodrome to increase support to the RDT&E for next-generation UK aerospace - *e.g.* drones (particularly non-military drones for good), electric aircraft, urban/regional air mobility vehicles, balloons, airships, near-space testing *etc*. The Statement of Need for the application is declared as follows:

- *To provide an environment for safe operation of all ongoing aerospace-related Research, Development, Test and Evaluation (RDT&E) activities in the vicinity of Llanbedr Airfield (EGFD) and the ability for associated aircraft to transit safely to/from Danger Area D201 to undertake extended range/endurance/altitude testing (in accordance with extant D201 procedures) without concern for other air traffic.*

The proposal explicitly supports the Airspace Modernisation Strategy (CAP1711) by creating a permanent test zone in which to explore the airspace integration issues associated with new airspace users such as drones that are currently identified as “unknowns” in Chapter 5 of CAP1711.

1.3. The cause of the opportunity and associated factors or requirements

The preface to the UK Government Aerospace Industrial Strategy, 2018, states that:

- *‘Environmentally-friendly aircraft will increasingly incorporate electric technologies, and we anticipate more aircraft operating autonomously in the future. New markets for drones and Urban Air Mobility vehicles will be developed. We want the UK to be at the cutting edge of these exciting developments much as we were when Sir Frank Whittle developed the world’s first jet engine’.*

Llanbedr has long been a UK national asset for aerospace RDT&E and there has been increased demand in recent years given its ideal location for Beyond Visual Line-of-Sight (BVLOS) drone testing. These activities have been satisfied to date by use of a Temporary Danger Area, but both customer demand and the need for confidence and reliance are now such that an application for a Permanent Airspace Change is warranted. The combination of safety, operational, technical and environmental factors already pertaining to low volume RDT&E activities is not expected to change.

Moving to a permanent Danger Area will allow an increase in throughput to satisfy the market need and provide UK businesses in these sectors with a surety of being able to operate in the UK on a reactive basis. Many UK businesses have chosen to undertake their testing abroad due to the uncertainties around availability of adequate and appropriate commercial trials environments. Figures 2a – 2f below gives an indication of some of the wide variety of novel aerospace systems and applications that have previously been tested at Llanbedr Aerodrome and which would benefit from a permanent Danger Area to help accelerate development and commercial exploitation.

***Fig. 2a** – Penguin B used to explore the potential for aeromedical delivery drones*

***Fig. 2b** – Vertical Aerospace electric Urban Air Mobility (UAM) vehicle*

***Fig. 2c** – Scheibel S100 Camcopter used to explore the potential for search/rescue drones*

***Fig. 2d** – Astigan solar-powered high altitude, long endurance (HALE) vehicle*

***Fig. 2e** – C-Astral Bramor used to explore the potential for mapping and surveying drones*

***Fig. 2f** – The view of Cardigan Bay from the B2Space near-space testing balloon*

2. Consultation preparation and Options Appraisal to date

2.1. CAP1616 requirements and document scope

The CAA Civil Aviation Publication CAP1616[6] provides guidance on the regulatory process for changing the notified airspace design and planned and permanent redistribution of air traffic, and on providing airspace information.

CAP1616 defines a six-stage process through to implementation of a permanent airspace change, some of which have more than one step. However, it is recognised that requested airspace changes can vary hugely in size, scale and complexity and this variation has led the CAA to scale the process accordingly (CAP1616, Para. 50). Furthermore, the CAA will consider requests from the Change Sponsor for additional scaling of the process when there is a good reason and it is proportionate to do so.

Snowdonia Aerospace has successfully completed Stage 1 (Define) and Stage 2 (Develop and Assess) and all the supporting documentation can be found on the CAA Airspace Change Portal[7]. At this point the CAA also determined that ACP-2019-58 was confirmed as a Level 1 change. The requirements for Stage 3A, Consultation Preparation, are as follows:

1. produce a draft Consultation Strategy detailing the scale, nature and timescales of the proposed consultation;
2. produce a draft Consultation Document that allows stakeholders – including those with no technical expertise – to understand the potential impact of the proposed changes;
3. produce an Options Appraisal (Phase II – Full) identifying potential impacts and mapping potentially affected stakeholders.

This document addresses the requirement for (3), the Options Appraisal (Phase II – Full).

The remainder of this section summarises the initial Phase I analysis from Stage 2B, restates the assessment of future airspace use as the context for Phase II, and sets out the strategy for the Phase II analysis. Section 3 then details the analysis itself and seeks to present the results in a plain English form that will allow a non-technical audience to assess any impact the proposed changes may have on them.

2.2. Summary of the Phase I (Initial) Options Appraisal

Stage 2B required the Change Sponsor to carry out an initial appraisal of the impacts of each of the airspace design options identified in Step 2A and, as a minimum, detail qualitative assessments of the different options. This highlighted to change sponsors, stakeholders and the CAA the relative differences between the impacts, both positive and negative, of each option. We also assessed each option against a “do nothing” scenario (the “counterfactual”).

The following points summarise the ACP-2019-58, Stage 2B analysis:

1. Snowdonia Aerospace assessed the impacts of the permanent Danger Area (DA) Design Options #1 and #2 proposed at Stage 2A (illustrated in Figure 3a and 3b below) against a “do nothing” option (*i.e.* continuing under a Temporary Danger Area) using the design criteria from Stage 1B;
2. In both cases, the permanent DA design provides an area of segregated airspace local to Llanbedr Aerodrome for the research, development, test and evaluation (RDT&E) of novel aerospace systems and an air corridor that will link Llanbedr Aerodrome with the existing Danger Area D201 over Cardigan Bay;

[6] Ref: https://publicapps.caa.co.uk/docs/33/CAP1616_Airspace%20Change_Ed_3_Jan2020_interactive.pdf
[7] Ref: https://airspacechange.caa.co.uk/PublicProposalArea?pID=193

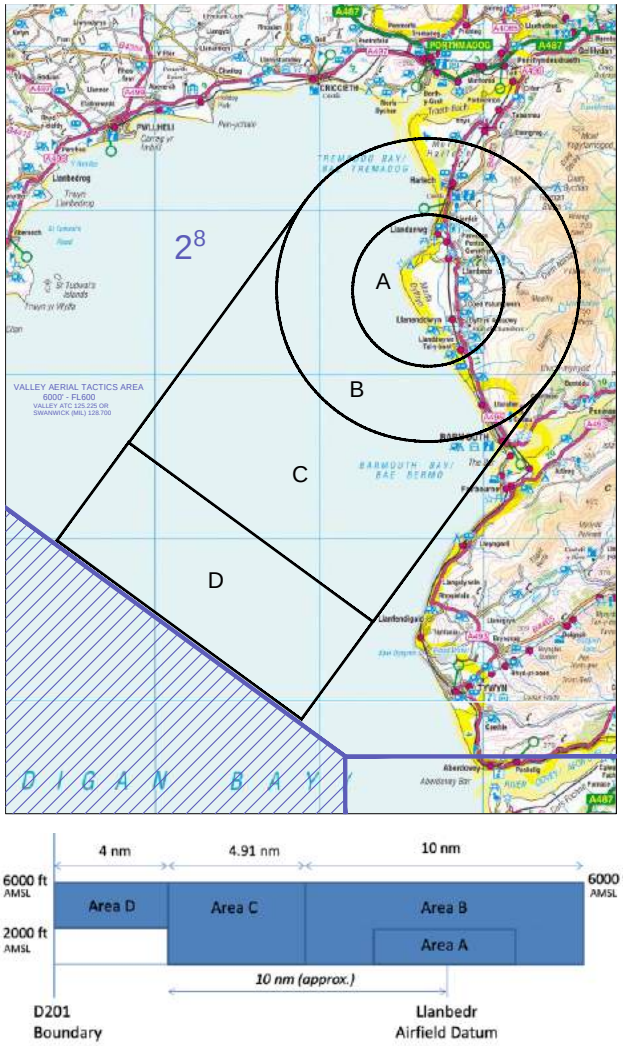

Fig. 3a *– Airspace Design Option #1 for ACP-2019-58, Llanbedr Danger Area*

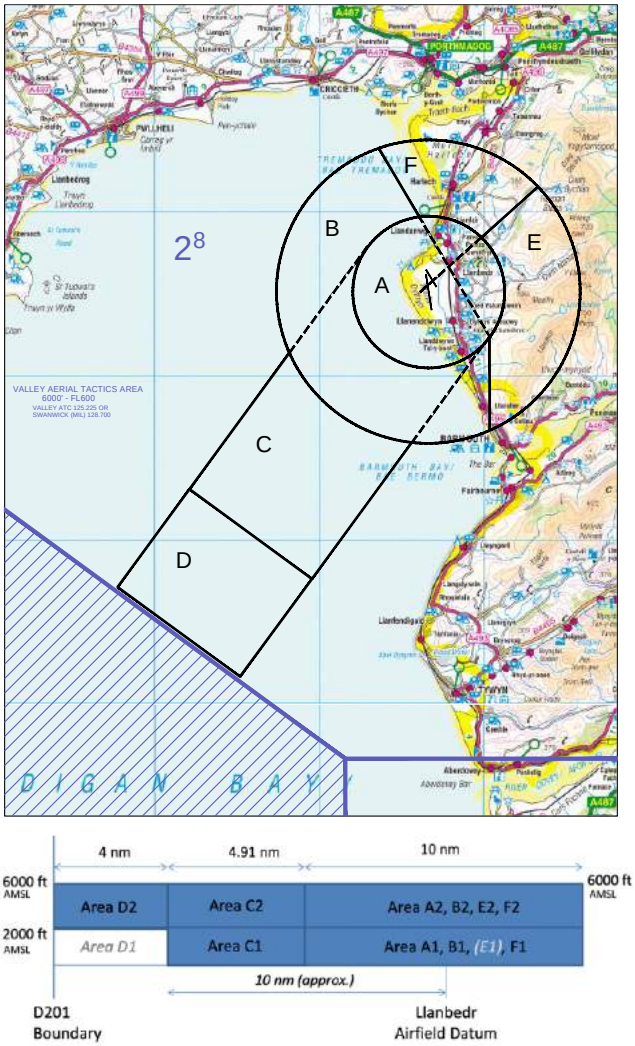

Fig. 3b *– Airspace Design Option #2 for ACP-2019-58, Llanbedr Danger Area*

3. The methodology applied a simple qualitative assessment of the different options, both positive and negative, against the CAP1616, Appendix E, Table E2: "Guide to expected approach to key analysis for a typical airspace change". This approach has been applied previously in other Airspace Change Proposals of similar scale/proportionality and it has been deemed compliant both with the spirit of CAP1616 and the Government Green Book;
4. The assessment highlighted a strong economic case for implementation of a permanent Danger Area on the basis that it will (a) significantly enhance the UK RDT&E capability in environmentally-friendly aircraft and electric technologies in accordance with the 2018 Aerospace Industrial Strategy, and (b) generate jobs and related economic benefit in local communities.
5. The number of novel aerospace system flight movements is expected to double (see Section 2.3 for more detail), but the numbers are relatively small (~100 days of Danger Area activation per annum and <200 flights per annum), the vast majority of operations (~90%) will be over the aerodrome or out over the sea and the vehicle size (the majority <150kg) and propulsion type (50%+ electric) mean that any noise and environmental impact is expected to be negligible;
6. On the basis of the safety, operational, environmental and economic considerations, the Change Sponsor recommended that the CAA consider the Llanbedr DA ACP favourably.

2.3. Assessment of future airspace use

With regard current novel aerospace RDT&E activity at Llanbedr Aerodrome, we've seen on-site occupancy increase from 30 days in 2017/18 to 40 days in 2018/19 and to 80 days in 2019/20. Looking ahead to the immediate future, both from existing demand together with support to the UK Research and Innovation Future Flight Challenge[8] we are forecasting, as a minimum, on site occupancy is going to double again to 160 days/annum in the period 2020 to 2024 and that growth in the novel aerospace industry is likely to sustain this figure into the longer term.

Translating this forecast of on-site occupancy into the demand for activation of the permanent Danger Area (DA) is not straightforward because of the wide variation in types of novel aerospace systems (examples of which are illustrated in Figure 2a – 2f) and the associated type-specific flight test and evaluation requirements, but it is useful to make an estimate of the breakdown for the probable utilisation of the sub-areas identified in Design Options #1 and #2 to determine any potential impact on other airspace users, the local community and the surrounding environment. Any estimate is obviously going to have a degree of uncertainty, but for the purposes of the CAP1616 Stage 2B and 3A Design Options Appraisal, we believe a reasonable approach is to apply a simple multiplicative cascade - *i.e.* we would expect the sub-areas further away from the aerodrome and / or at higher altitude to be used less - and that the respective probabilities associated with each step have been determined based on a mix of prior experience and market knowledge:

- We expect there to be a 66.6% probability (*i.e.* twice as likely as not) that we will need to activate the DA on any day when the airfield is supporting a novel aerospace system activity;
- We then expect there to be a similar 66.6% probability that we would need to activate more than one sub-area (Area A + Area B/C/D *etc*.);
- We further expect there to be a 66.6% probability that the additional sub-areas will be adjacent to Area A - *i.e.* Area B for Option 1 or Area B/E/F for Option 2 - and a corresponding 33.3% probability that the novel aircraft system would need to enter the Area C/D corridor;
- For Option #2 we would also expect there to be a 75% probability (*i.e.* three time as likely as not) that Area B would be activated in preference to Areas E or F;
- Again, for Option #2, if over-land sub-areas of the DA need to be activated, there is expected to be a 50% probability that it will be Area E or F;
- Finally, regardless of Design Option or sub-area, we expect there to be a 66.6% probability that the maximum altitude required will be 2000ft and a corresponding 33.3% probability that the maximum altitude required will be 6000ft.

Assuming a minimum target of 160 days occupancy per year, this gives the following predicted number of days Danger Area activation per year for each the various sub-areas:

	Design Option #1	Design Option #2
Area A (over the aerodrome)	107	107
Area B* (inshore+)	47	35
Area C/D (offshore corridor to D201)	24	24
Area E (coastal lowland / Harlech)		6
Area F (toward Rhinog mountains)		6
Max. altitude <2000ft	71	71
Max. altitude <6000ft	36	36

***Table 1** - Estimate of DA annual daily usage (*Note - Option #1, Area B = Option #2, Area B+E+F)*

[8] Ref: https://www.ukri.org/innovation/industrial-strategy-challenge-fund/future-flight1/

To complete the forecast, it is also reasonable to estimate that it's again twice as likely as not (66.6%) that the novel aerospace systems operating at Llanbedr Aerodrome will have a maximum take-off weight less than 150kg (*i.e.* small / light drones) and that the split between internal combustion engine/jet-powered aircraft and electric-powered aircraft will be roughly 50:50, but with an increasing bias toward electric-powered aircraft over time.

The estimate of 100 days of Danger Area activation per annum and 200 novel aerospace system flights per annum (approximately) also needs to be set in the context of 1000 totals aircraft movements at Llanbedr during 2019 (approximately) and a historical average of 9500 movements per year (approximately) in the period prior to QinetiQ/MOD vacating the site in 2004.

Please note that these estimates are indicative only and intended primarily to show the usage of the various sub-areas relative to each other and to allow any potential impact on other airspace users, the local community and the surrounding environment to be determined. We have quoted daily occupation as the key metric as this is easier to predict and there are historical records for the past three years to back this up, but in terms of actual flights / aircraft movements, it would be reasonable to assume two flights on any given day as a guide. This estimate is also based primarily on a forecast of drone and electric aircraft operations in the period up to 2024. Beyond this period, we would expect a small but increasing number of space-related activities to increase the proportion of operations using the air corridor to connect to the D201 Cardigan Bay Range.

2.4. Hours of operation

The standard operating hours for Llanbedr Aerodrome are 0900 to 1700 on Monday to Friday and typically we would only expect the Danger Area to be activated during these periods and then only when required. However, there may be a requirement for some trials platforms (*e.g.* HALE platforms, an example of which is shown in Figure 2d) to take advantage of lighter wind conditions, typically early morning or late evening, and consequently the operating hours will be extended as required to accommodate this activity. In these circumstances the aim again would be to promulgate the activity Monday to Friday, but these operations are expected to have very little impact (if any) on other airspace users. Furthermore, there may also be situations - *e.g.* where a short duration trial has been delayed by weather - where a limited amount of weekend flying may be required. We anticipate that any operations outside of standard hours will only be in exceptional circumstances and very rare in occurrence. As much notice as possible will be given to other airspace users.

2.5. Flexible Use of Airspace

European Commission Regulation (EC) No 2150/2005 of 23 December 2005[9] lays down common rules for the flexible use of airspace (FUA), defined as follows:

- *"Flexible use of airspace is an airspace management concept described by the International Civil Aviation Organisation (ICAO) and developed by the European Organisation for the Safety of Aviation (Eurocontrol), according to which airspace should not be designated as either purely civil or purely military airspace, but should rather be considered as one continuum in which all users' requirements have to be accommodated to the maximum extent possible".*

In the UK, CAP 740, UK Airspace Management Policy[10], serves as a means of compliance to the essential requirements of both Reg (EC) 2150/2005 (Flexible Use of Airspace Regulation) and Reg (EU) 373/2017 (Common requirements for providers of air traffic management / air navigation services). CAP 740 also ensures compliance with supporting Eurocontrol guidance. With regard FUA and its application to the Llanbedr Danger Area, the key requirement is stated in CAP740, Appendix A (UK Flexible Use of Airspace Strategy), Paragraph 7b:

[9] Ref: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R2150&from=EN
[10] Ref: https://publicapps.caa.co.uk/docs/33/CAP740_Issue7_Am1_Nov_2019(cor).pdf

- *Minimise airspace segregation by activating airspace volumes based on need rather than routine activation through set times defined in the AIP11. Where possible the routine activation should be by Notice to Airmen (NOTAM) to facilitate Strategic Airspace Management.*

It is the Change Sponsors intention to fully follow these stated principles within the design and operation of the proposed ACP-2019-58 for the Llanbedr Danger Area. Appendix C (Military ASM Policy) shall also be considered, where possible, when it applies to a civil DA.

2.6. Displacement of other aviation

Displacement of other aviation as a result of Danger Area activation is principally going to affect those aircraft wishing to overfly Llanbedr, of which 77 instances were recorded in the airfield movement log for 2019[11].

Aircraft wishing to transit past Llanbedr will still be able to do so even if the DA is active. The combination of the ATZ (assuming successful conclusion of ACP-2020-02), the FIS service, and the explicit horizontal and vertical segmentation of the Danger Area in Option #2, will allow other air traffic to safely transit over the DA (above 2000ft) and past the DA to the west or east depending on which areas have been activated. The same capability to transit over the DA will also exist with Option #1 as the full 6000ft altitude will only be activated if required. On the estimated 36 days/year when the 6000ft maximum altitude may be in effect (*i.e.* 10% of the year, affecting 7 aircraft on average), the maximum lateral deviation from path will only be the 2.5 nautical miles required to avoid Area A.

The Airspace Change is anticipated to have a negligible impact on displacement of other aviation.

2.7. Strategy for the Phase 2 (Full) Options Appraisal

Before undertaking the Phase 2 activities, SAC engaged the services of Osprey Consulting Services to seek their advice on conducting the Full Options Appraisal, given their experience with previous ACPs and the challenges presented by the unique aspects of SAC's business at Llanbedr. Llanbedr is not a commercial aerodrome with conventional commercial air traffic and, with regard the Danger Area ACP, the changes sought are very minor in comparison to those accompanying a full range of new instrument flight procedures at a large international airport, for example.

As a result, sources of quantitative data derived from modelling airport operations and aircraft movements are not available at a level sufficient to support a standard assessment that quantifies and monetises the environmental impacts of implementing the proposed change using the Department for Transport WebTAG tool. For example, quantitative noise metrics would usually be used to support the baseline case, but Noise and Track Keeping (NTK) system data is not available at Llanbedr as the level of movements is insufficient to justify the installation of the supporting infrastructure and there is no airport CHROMA data base; there is no business or regulatory basis to collect this level of data. Neither is it possible to generate overflight contours.

Instead, we believe a scaled approach to the environmental impact assessments is appropriate and proportionate, while still meeting the requirements and intent of CAP 1616, where alternative sources of evidence are provided to enable the consulted communities to understand any impact of the proposed airspace change against a number of environmental factors. There is precedent in the St Athan ILS ACP (ACP-2018-35) for making a justification for a more limited environmental analysis than would be required for a more conventional ACP.CAP 1616 requires consideration of the following environmental factors for Level 1 proposals (which includes ACP-2019-58):

- Noise
- Overflight
- CO_2 emissions
- Local air quality

[11] Ref: Snowdonia Aerospace, Llanbedr Aerodrome Movement Record 2019

- Impacts on tranquillity
- Impacts on biodiversity

In consultation with Osprey Consulting Services[12], our adopted approach for the Phase II (Full) Appraisal is to address all of these environmental factors in turn, compare the Danger Area design options against the "do nothing" option (continuing with the Temporary Danger Area), and present a mix of quantitative and qualitative evidence based on the following data sources:

- Current air traffic records;
- Estimate of future air traffic as a result of the ACP (see Section 2.3);
- Comparison with referenced papers for drone noise and other known noise/pollution sources that will be familiar to non-technical stakeholders (*e.g.* military aircraft, general aviation aircraft, helicopter, road traffic *etc*.);
- A representative recent R&D drone example (internal combustion engine, flight profile ground footprint and fuel burn);
- A representative future R&D drone example (jet engine, flight profile ground footprint and fuel burn).

We will also seek to interpolate and extrapolate from the above data to estimate any environmental impact and allow non-technical stakeholders to understand any potential impact of the proposed changes. We believe this approach to be both appropriate and proportionate for the Llanbedr Danger Area ACP and compliant with CAP1616 and the Government Green Book[13].

The Phase II (Full) Appraisal is presented in Section 3.

2.8. Baseline

The established use for the site is as an operational airfield and its recognised historic and current / ongoing uses. The site has an existing Certificate of Lawfulness (Ref: NP5/62/LU372) for research and development for testing, evaluation and development of drones and has a current planning consent for a mixed use incorporation, both its established use and for aircraft maintenance, including decommissioning and disassembly, parts recovery, refitting and engineering training (Ref: NP5/62/372A).

Within the Eryri (Snowdonia) Local Development Plan (2016–2031) (ELDP), the site is allocated as:

- *"The preferred location for high quality aerospace and low carbon technology enterprises, maximising the unique characteristics and strategic asset of the site; building upon its location at the heart of the National Park to help transform the area's economic prospects"*

And for:

- operations and uses associated with the aviation and aerospace industry, including those associated with airfield infrastructure and services and airspace management;
- new uses including employment use (B1, B2, B8) and other uses associated with research and development (including aviation and aerospace industries);
- employment-related training and education purposes;
- other uses ancillary to the uses identified above including accommodation, catering and leisure.

The existing consents and Local Plan allocations have been through extensive community and stakeholder engagement particularly in the context of the sites use and its location and no particular issues have been raised in the context of the planned and allocated uses against these matters.

[12] Ref: "Danger Area ACP Support to Step 3a - Environmental Scaling Justifications", Osprey Ref: 71469 002, October 2020
[13] Ref: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

3. Phase II (Full) Options Appraisal

3.1. Summary of options appraisal against "do nothing"

Table 2 summarises the appraisal of the Llanbedr Danger Area options and the "do nothing" options against the high-level objectives and assessment criteria laid out in CAP1616, Appendix E, Table E2, as originally described in the Stage 2B analysis. There are no commercial airline operations in the vicinity of Llanbedr, but there is a significant amount of military aircraft training and hence the options appraisal has been conducted in this context and references to "commercial airline" within CAP1616 have been interpreted as "RAF/MOD".

Group	Impact	DA Option #1	DA Option #2	"Do nothing"
Communities	Noise impact on health and quality of life	• The number of novel aerospace system movements is expected to double, but numbers are relatively small (~100 DA days/annum, <200 flights/annum), and vehicle size (majority <150kg) and propulsion type (50%+ electric) means the noise impact is likely to be negligible. The vast majority of operations (~90%) will also be over the aerodrome or out to sea. Systems that deviate notably from the norm can be managed by Letter of Agreement with the local communities		• There would be little or no change from present
Communities	Air quality	• As above, there is expected to be little impact on air quality		• There would be little or no change from present
Wider society	Greenhouse gas impact	• As above, there is expected to be little direct impact and a strong element of the RDT&E activities will be focussed on reducing greenhouse gases in aviation		• There would be little or no change from present
Wider society	Capacity / resilience	• A permanent DA will significantly enhance the UK RDT&E capability in environmentally friendly aircraft and electric technologies and allow UK Govt. to move closer to the goal stated in the Aerospace Industrial Strategy, 2018 for "the UK to be at the cutting edge of these exciting developments". A permanent DA also supports the Airspace Modernisation Strategy by creating a test zone in which to explore the airspace integration issues associated with new airspace users such as drones that are identified as "unknowns" in Chapter 5 of CAP1711.		• Similar to the permanent DA, but at much reduced capacity, and makes the assumption that the TDA can be renewed indefinitely
General Aviation	Access	• The current level of GA traffic (789 movements in 2019)[9] is unlikely to be unduly impacted by the DA, which is estimated will be active 2 days / week on average. Related operational issues could be managed via Letters of Agreement.	• As per Option #1, but with the potential for increased flexible use of airspace via greater DA segmentation and with mechanisms in place for safe transit to west, east or above the DA (above 2000ft) depending on which sub-areas are active.	• There would be little or no change on General Aviation operations in the vicinity of Llanbedr from the present position
RAF	Access	• Despite a predicted increase in both RDT&E flying and RAF/MOD training, there is still considered to be sufficient capacity to accommodate all activities safely with appropriate mechanisms identified for spatial and temporal deconfliction. It is estimated the DA will be active 2 days / week on average and with	• As per Option #1, but with the potential for increased flexible use of airspace via greater DA segmentation and with mechanisms in place for safe transit to west, east or above the DA (above 2000ft) depending on which sub-areas are active.	• There would be little or no change on RAF/MOD operations in the vicinity of Llanbedr from the present position

		operations above 2000ft likely only 33% of the time. Related operational issues could be managed via Letters of Agreement.		
General Aviation / RAF	Economic impact from increased effective capacity	• There is not expected to be any economic impact on General Aviation or RAF/MOD		• There would be little or no change from present
General Aviation / RAF	Fuel burn	• General aviation and RAF/MOD fuel burn is not expected to change		• There would be little or no change from present
RAF	Training cost	• *Not applicable*		• *Not applicable*
RAF	Other costs	• *Not applicable*		• *Not applicable*
Airport / ANSP	Infrastructure costs	• There will be a need for further investment into the Aerodrome facilities to implement a UTM system. These costs are being borne by Snowdonia Aerospace LLP as part of its ongoing investment programme at the Aerodrome		• As per Option #1
Airport / ANSP	Operational costs	• There may be a need for increased Flight Information Service (FIS) and Rescue & Fire-Fighting Services (RFFS), but this cost will be borne by Snowdonia Aerospace LLP • *See also economic impact*		• As per Option #1
Airport / ANSP	Deployment costs	• There may be a need for additional FIS and RFFS training, but this cost will be borne by Snowdonia Aerospace LLP • *See also economic impact*		• As per Option #1
Airport / ANSP	Economic impact from increased effective capacity	• A recent economic impact assessment[14] suggested a multi-use aerospace site at Llanbedr (with aerodrome licencing, ATZ and DA implementation as fundamental building blocks) could contribute 515 jobs and £19.5m/annum of GVA at the local level and 765 jobs and £34m/annum of additional GVA in Wales over the next 10 years		• Not having a permanent DA will remove one of the fundamental building blocks associated with development of Llanbedr as a multi-use aerospace site and jeopardise the predicted economic benefit to the local community

***Table 2** – Summary of the options appraisal for Llanbedr Danger Area and "do nothing" options*

The following Sections 3.2 to 3.11 expand on each of the key environmental, safety, operational, and economic issues identified in Table 2 and present a more detailed analysis.

3.2. Noise

Noise measurement and interpretation is a hugely complex matter. In the following sections, in order to help non-technical stakeholders better understand any potential impact of the proposed airspace changes and the type of air vehicles that will be operating from Llanbedr as a result, we will (*i*) start with some basic definitions and rules of noise measurement and perception, (*ii*) show how drones (and other novel aerospace systems) compare to a range of other familiar noise sources, and (*iii*) give an indication of how the noise from such aircraft may impact the environment around Llanbedr.

[14] Wavehill Ltd, "Economic Impact Assessment for the Masterplan Development Proposals for the Snowdonia Aerospace Centre incorporating Spaceport Snowdonia at Llanbedr Airfield", 12th March 2020

The analysis is necessarily simplified as there is a lack of definitive source data and noise propagation from any given source is subject to a large number of influencing factors (which are outside of scope at present), but it is considered sufficient to give a representative and quantifiable assessment of scale and impact for the purposes of the ACP consultation. Overflight over other areas within the proposed Danger Area beyond Llanbedr will be addressed in Section 3.3.

3.2.1. Definitions

Decibel: the decibel (symbol: dB) is a relative unit of measurement corresponding to one tenth of a bel (B). It is used to express the ratio of one value of a power or field quantity to another on a logarithmic scale and is commonly used in acoustics as a unit of sound pressure level.

The decibel scale: the reference pressure for sound in air (0dB) is set at the typical threshold of perception of an average human and there are common comparisons used to illustrate different levels of sound pressure or “noise” (Figure 4).

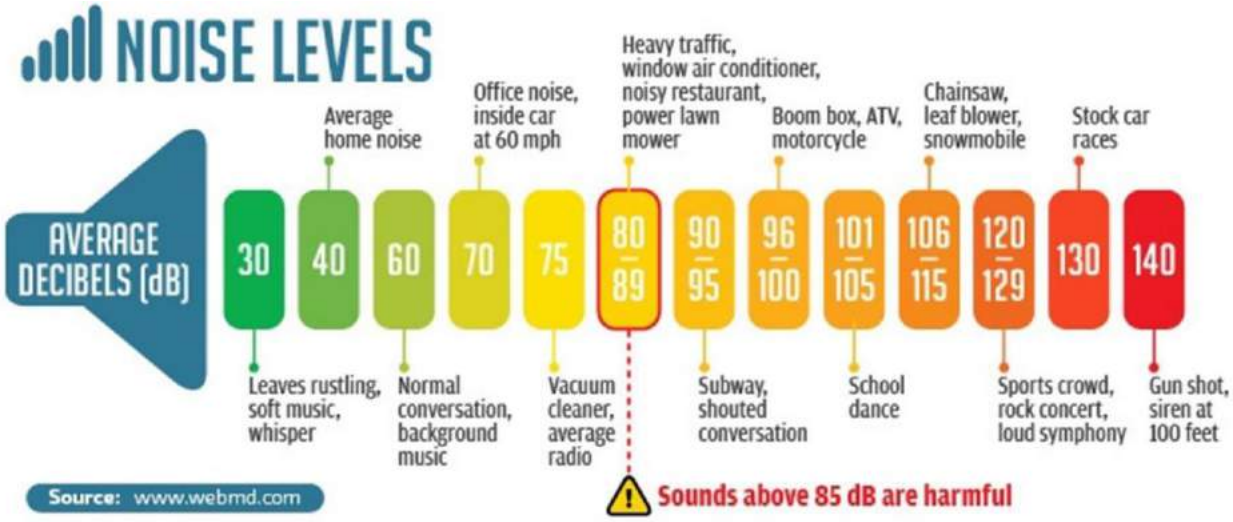

Figure 4 *- common comparisons used to illustrate different levels of sound pressure on the dB scale*

3dB rule: every time you double a pressure level there is a 3dB increase. Conversely, cutting the pressure level in half will result in a 3dB decrease. For example, if a pin dropping has a sound pressure level of 10dB then two pins dropping would have a level of 13dB.

10dB rule: an increase of 3dB doubles the sound pressure level, but a 10dB increase is usually required before a sound is perceived to be “twice as loud”. For example, with reference to Figure 4, office noise at 70dB will be perceived by a listener to be twice as loud as normal conversation at 60dB, and a noisy restaurant at 80dB will be perceived to be four times as loud.

A-weighted or dB(A): a measurement that has been adjusted to consider the varying sensitivity of the human ear to different frequencies of sound where low and very high frequencies are given less weight than on the standard decibel scale. Many regulatory noise limits are specified in terms of dBA, based on the belief that dBA is better correlated with perception of noise and the relative risk of noise-induced hearing loss.

85dB / 85dB(A) threshold: UK employers must provide hearing protection at 85dB(A) (daily or weekly average exposure) and the level at which employers must assess the risk to workers' health and provide them with information and training is 80db(A).

Ambient noise: noise from an aircraft is only relevant to the extent that it does not exceed ambient (background) noise levels, which obviously differ from central business districts (CBD) to suburban to rural conditions, as well as from day to night-time (Figure 5).

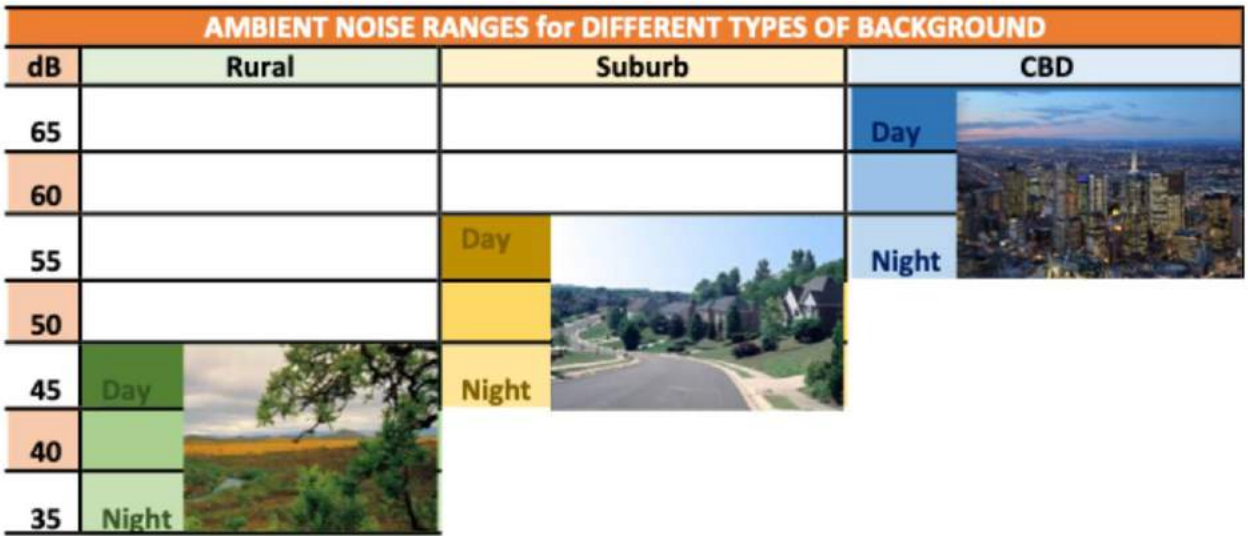

Figure 5 *– Ambient noise ranges for different types of background*

Noise propagation: Sound is a sequence of pressure waves that propagate (travel) through compressible media such as air or water. (Sound can propagate through solids as well, but there are additional modes of propagation). During their propagation, waves can be reflected, refracted, or attenuated (reduced) by the medium. Typically, sound waves propagate as a sphere and follow an "inverse square law" of level reduction – *i.e.* the level reduces four-fold (6dB) for every doubling of distance from the source, although additional factors such as wind, temperature and surface barriers (buildings, trees etc.) will also have an effect.

3.2.2. Drone noise

There are as yet no standard noise models for drones or standard measurement processes as there are for conventional manned aircraft.

Multiple internet references can be found for drone noise measurements, but these almost exclusively relate to consumer drones (*e.g.* DJI Phantom, Mavic *etc*.) and usually quote figures in the 70bB to 75dB range, although this rarely includes the distance from the source at which the noise was measured (although typically it is "close" – *i.e.* 5 metres or less), which makes comparison with other standard noise measurements difficult.

Having said that, there is a general consensus that small drones have a similar sound level to cars, but can be perceived to be more of an annoyance because of their higher frequency content. Christian and Cabell (2016) determined that this annoyance factor was equivalent to an approximate 6dB offset[15] – *i.e.* a drone at 70dB is perceived to be as annoying as a car at 76dB. The major sources of drone noise are the engine / motor (petrol or electric) and the propellor (fixed-wing) or rotor(s) (rotary-wing) with the latter also generating noise peaks at multiple harmonics of the blade passing frequency.

Manufacturers have started to address noise as a major issue and simple changes to the rotor shape and motor controller can have a dramatic beneficial effect – *e.g.* the latest DJI Mavic Pro Platinum is 4dB to 6dB quieter than the previous DJI Mavic Pro[16].

Airborne Drones quote the following comparison of drone noise with conventional aircraft noise (all measured at ground level with the aircraft at an altitude of 100m (330ft))[17] (Table 3a):

[15] Christian and Cabell, "Initial investigation into the psychoacoustics properties of small unmanned aerial system noise", Proceedings of the 17th AIAA Aviation Technology, Integration and Operations Conference, 2016
[16] Ref: https://dronedj.com/2017/09/28/video-detail-on-the-noise-levels-of-the-dji-mavic-pro-platinum-vs-dji-mavic-pro/
[17] Ref: https://www.airbornedrones.co/drone-noise-levels/

Aircraft type	Sound Pressure Level @ 100m AGL
Small fixed-wing drone *e.g.* AeroVironment Raven	50dB
Large quadcopter *e.g.* DJI Mavic Pro	55dB*
Small manned fixed-wing aircraft *e.g.* Robin DR400	75dB
Manned helicopter	95dB

*Consistent with the previously quoted measurement of 75dB "close-in" from other sources

Table 3a *- Comparison of drone noise with conventional aircraft noise (measured at ground level with the aircraft at an altitude of 100m)*

Drones such as the Raven and Mavic are useful benchmarks, but the drones / novel aerospace systems that will fly at Llanbedr are typically larger, as illustrated previously in Figure 2a to 2f. There is even less published noise data for these classes of vehicles, but we have found test data for a light tactical drone, believed to be an AAI Shadow 200, that was collected by the Georgia Tech Research Institute (GTRI) in 2010[18]. The Shadow has a 3.9 metre wingspan, 180kg maximum take-off weight, and is powered by a 38hp Wankel 741 engine. The extensive GTRI dataset showed that the noise profile for the 1990's vintage Shadow is similar to that of a manned fixed-wing aircraft as quoted in Table 2a above, although advances in propellor and engine technology since then are likely to deliver a similar 4dB to 6dB improvement to that seen in the consumer market if the tests were to be repeated today. Last but not least, the most likely / most frequent type to operate at Llanbedr is the UAV Factory Penguin B drone that Snowdonia Aerospace have used previously to explore the potential for aeromedical delivery drones (Fig. 2a and also Fig. 6). The Penguin has a 3.3 metre wingspan, a 21.5kg maximum take-off weight, a dash speed of 36 ms^{-1} (70 knots) and is powered by a 28cc, 2.5hp two-stroke, single-cylinder petrol engine.

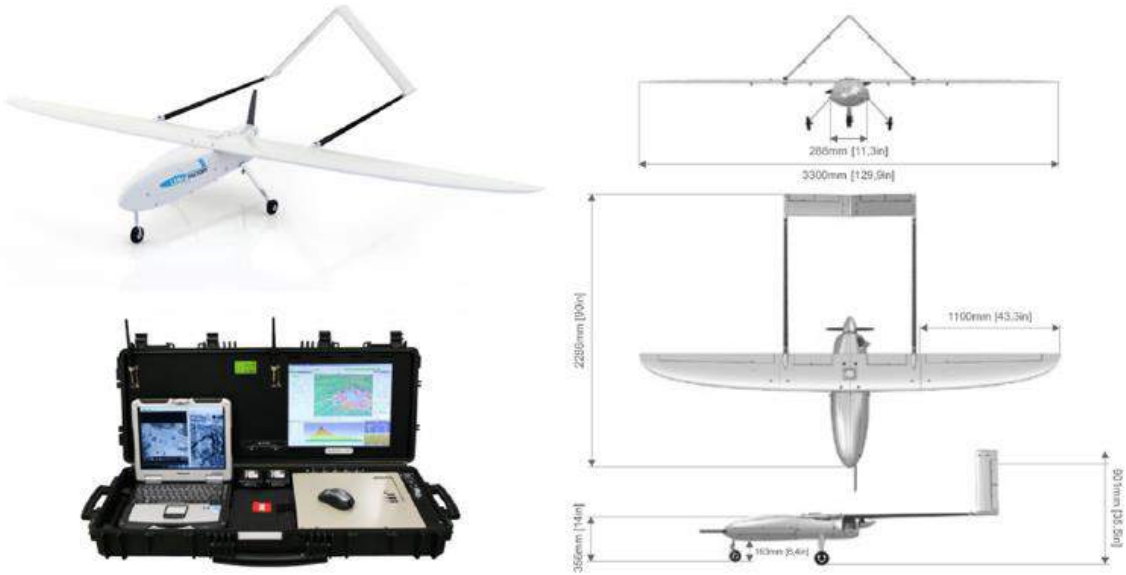

Figure 6 *- the UAV Factory Penguin B drone*

For the purposes of the consultation, and to give stakeholders a more representative baseline against which to assess any environmental impact, we have interpolated between the existing data to construct additional noise estimates for a 20kg maximum take-off weight drone (*e.g.* a Penguin) and a 150kg drone (*e.g.* Shadow or similar) at 100m above ground level (Table 3b):

[18] Ref: Massey and Gaeta, "Noise Measurements of Tactical UAVs", Proc. of the 16th AIAA/CEAS Aeroacoustics Conference, 2010

Aircraft type	Sound Pressure Level @ 100m AGL
Small fixed-wing drone *e.g.* AeroVironment Raven	50dB
Large quadcopter *e.g.* DJI Mavic Pro	55dB*
20kg MTOW drone e.g. UAV Factory Penguin B	*60dB***
150kg MTOW drone e.g. AAI Shadow 200	*70dB***
Small manned fixed-wing aircraft *e.g.* Robin DR400	75dB
Medium manned helicopter	95dB

* Consistent with a measurement of 75dB "close-in", ** Estimated

Table 3b *- Comparison of drone noise with conventional aircraft noise (measured at ground level with the aircraft at an altitude of 100m) for classes of vehicle likely to operate at Llanbedr Aerodrome*

As a final point of reference, this Airspace Change is not associated with military aircraft activity, but the jets are a familiar sight and sound at Llanbedr and over North Wales and a high speed, low-level pass would typically register somewhere in the region of 100dB to 120dB[19] – *i.e.* up 32 times louder than the RDT&E activity planned for Llanbedr under this ACP Proposal.

3.2.3. Impact on the local environment

Figure 7 takes the baseline data from Table 3b and estimates the further attenuation of the sound pressure level for each aircraft with increasing horizontal distance based on the inverse square law. Note that increasing altitude would have the same effect.

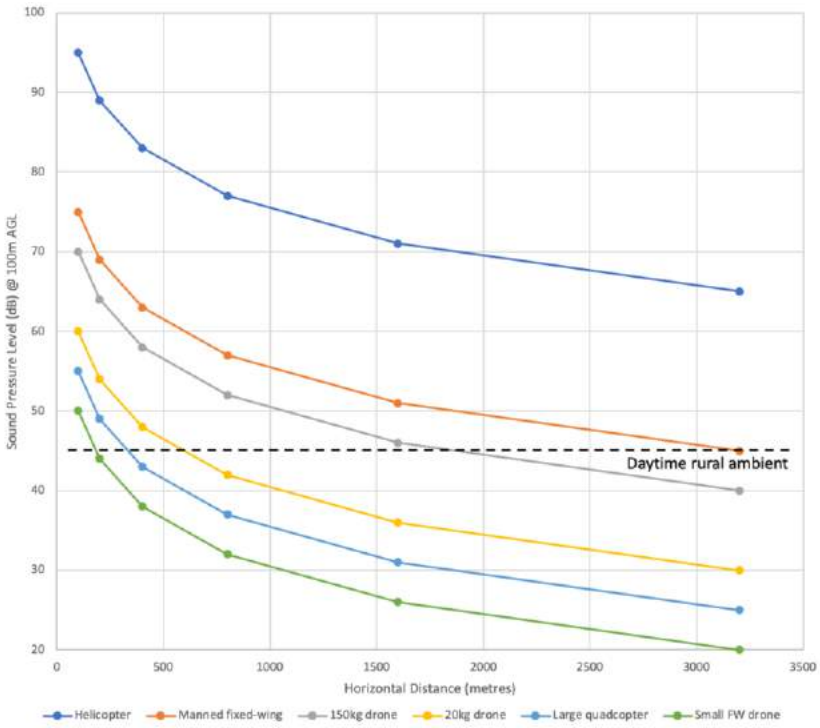

Figure 7 *– Estimated attenuation of sound pressure level at 100m above ground level with increasing horizontal distance for various aircraft types likely to operate at Llanbedr*

Figure 7 also includes the baseline for ambient noise in a daytime rural environment. This shows that all of the smaller drones are effectively inaudible above background noise beyond a few hundred metres, which tallies with our anecdotal experience.

[19] C. Lomax, G. Kerry and D.J. James, "Wideband noise signatures from low altitude military jet overflights", The Journal of the Acoustical Society of America 103(5), 1998

The C-Astral Bramor (a small electric fixed-wing drone, Fig 2e) was inaudible to ground observers when flying at altitudes above 150m / 500ft along the beach at Morfa Dyffryn and the UAV Factory Penguin B was only audible to ground observers on a similar stretch of beach when it came within a range of 500m (approximately) at an altitude of 100m / 330 ft. To put these estimates in the context of the local environment around Llanbedr Aerodrome, we have calculated the shortest distance from the intersection of Runway 15/33 and 05/23, which is our typical drone launch point and centre point for airfield circuits, to a number of local landmarks:

- 1000m: railway line;
- 1500m: Shell Island campsite, Morfa Dyffryn beach;
- 2000m: Llanbedr village;
- 2500m: Dyffryn Seaside Estate caravan park;
- 3000m: Dyffryn Ardudwy and Llanfair villages.

From our projections of future utilisation, we estimate that at least 66% of the drones that will operate from Llanbedr will have a maximum take-off weight less than 150kg and hence airfield operations are unlikely to be audible to local residents (temporary or permanent)[20] during normal daytime operation. Of the remaining 33% of drones / novel aerospace systems, representing about 30 days of operation per year, it is unlikely that noise profiles will be noticeably different from any other conventional fixed-wing general aviation or helicopters that use the airfield. It should also be noted that SAC and Gwynedd Council have not received a single noise complaint since the Temporary Danger Area was first activated in 2015.

As noted previously, this analysis is very simplified and will be subject to some inaccuracy, but we believe the bounds of that inaccuracy are still sufficient to give a representative and quantifiable assessment of the scale and impact on the local environment.

The Airspace Change is therefore anticipated to have a negligible impact on perceived noise.

3.3. Overflight

Unlike a conventional airport, there are no set flight profiles for the novel aerospace system activities conducted at Llanbedr, so it is highly unlikely that any area will be overflown on a regular basis. Indeed, due to the experimental nature of the activities, SAC work with each of the flight test teams to minimise overflight of buildings and property and the aircraft autopilots typically have in-built geo-fencing boundaries that prevent them from overflying sensitive areas or leaving the Danger Area.

To give stakeholders an indication of the type of flight profile that might be typical for RDT&E activity using the Danger Area, Figure 8 shows the flight plan and aircraft track for one of our recent sorties with the Penguin B drone to explore the potential for aeromedical delivery to a remote location. The green dots denote pre-programmed waypoints (WP) for the autopilot that were defined to allow us to fly different circuits over the airfield and confirm the function on the onboard systems before transitioning out over the coast to perform the mission demonstration. The red line shows the aircraft ADS-B (GPS) track that was overlaid on the Ground Control Station mission plan in real-time with the defibrillator drop performed at WP10. Before conducting this trial activity we gained permission from Gwynedd Council to access the beach, we scheduled the flight for a weekday afternoon when the beach was near-deserted, we made sure that the drone was always more than 50m away from all people and property (as per CAA guidance) and we stationed our own observers on the beach who were equipped with a megaphone, fire extinguisher and first aid kit and who were in continuous ground radio contact with both the drone pilot and the Flight Information Service Officer (FISO) in the Llanbedr Air Traffic Control tower.

[20] Any statutory noise limits only apply to permanent residents

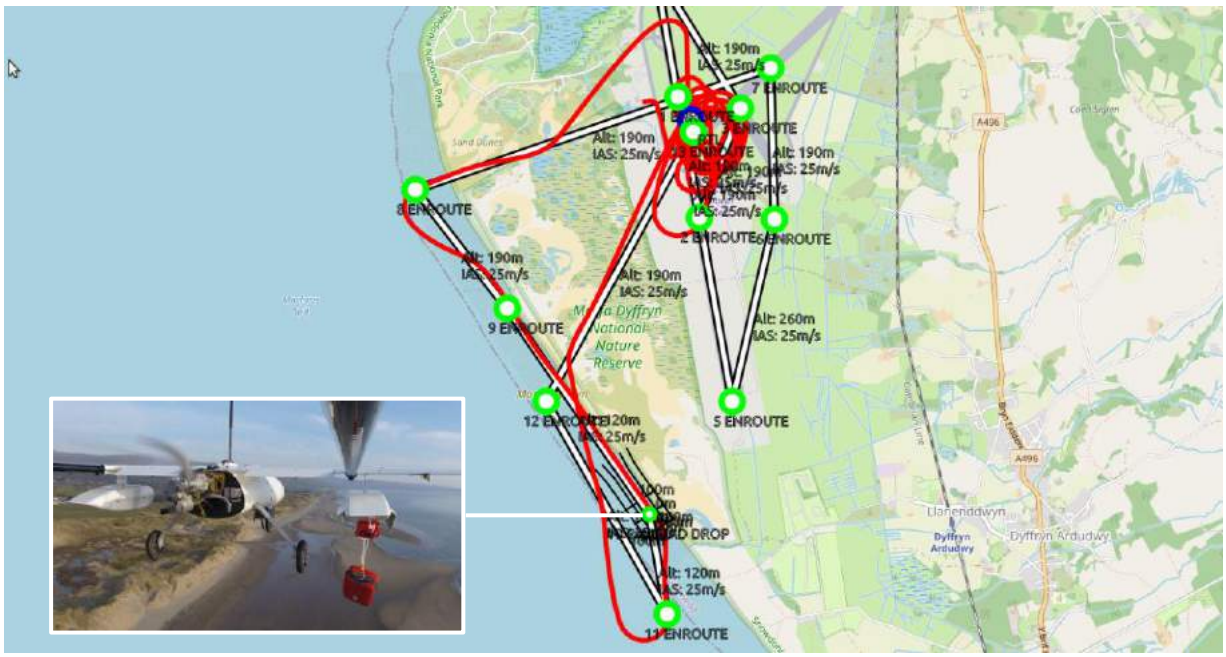

Figure 8 *– Ground Control Station pre-mission plan and overlaid aircraft ADS-B (GPS) track for flight of the Penguin B drone to explore the potential for aeromedical delivery to a remote location*

As noted above, the drone was only audible (and visible) to the ground observers when it came within a range of 500m (approximately) at an altitude of 100m / 330 ft. With the drone travelling at 25ms^{-1} the "time of exposure" was less than a minute as it completed the loop from WP10 to WP11 before disappearing from sight and sound again near WP12. We also made sure to minimise the flight time over the Site of Special Scientific Interest (SSOI) along the western boundary of the airfield and transitioned over this area at a higher altitude (190m / 625ft) to further reduce the noise profile.

Figure 9 shows a simulation-based flight path visualisation for a more extensive future trial activity with a small jet-powered drone planned for Summer 2021:

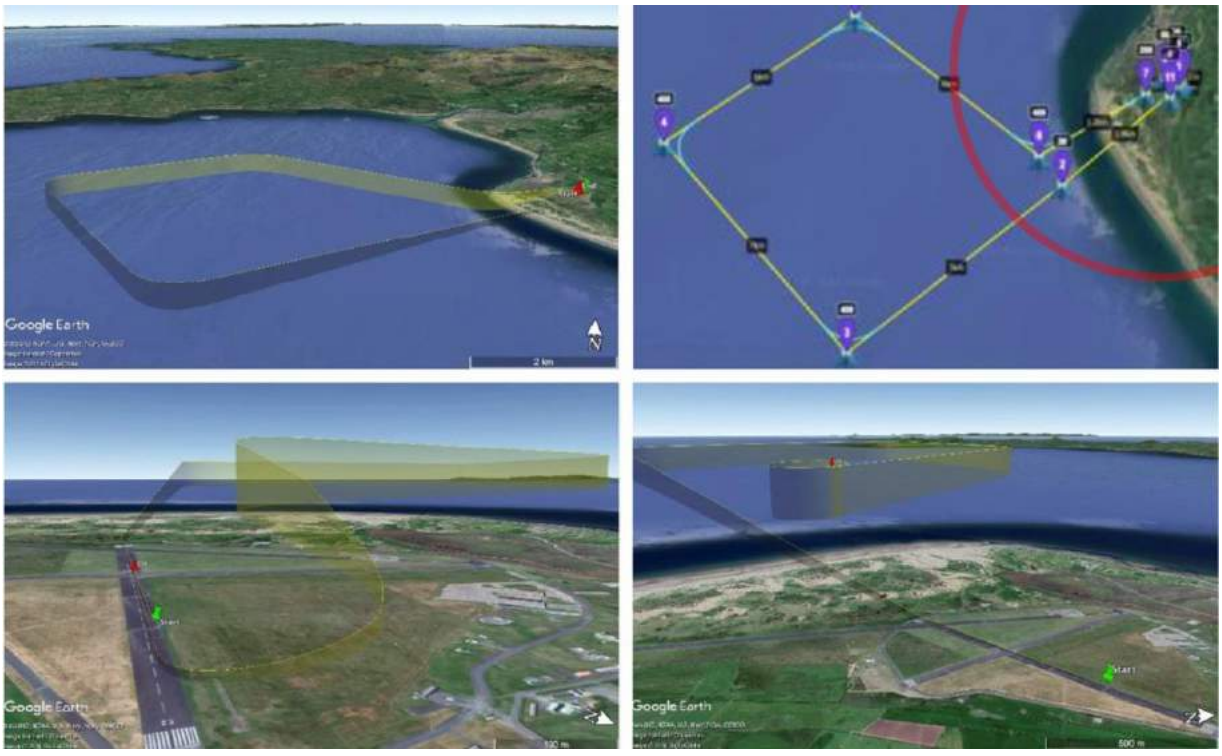

Figure 9 *– simulation-based flight path visualisation for a small jet-powered drone flight test*

Figure 9 again shows a series of pre-programmed waypoints that will be used to define the aircraft flight track, with a simple circuit in the vicinity of the airfield and the mission profile offset out over the sea. In this instance, the total flight time will be 15 minutes and the aircraft track length will be 35km with the clipped red circle (top-right subfigure) representing the boundary of Area A that is a core feature of both Design Option #1 and #2.

We estimate that approximately 90% of flight trials using the Danger Area will be conducted over the aerodrome or out over the sea in a similar manner to the examples shown in Figures 8 and 9 (or transition down the Area C/D corridor into the larger D201 Cardigan Bay Danger Area). In addition to simple circuits and linear transits, we might also expect to see standard mapping and search profiles as shown in Figure 10. These will typically be of the order of 1km square (although the creeping line mapping profile might be further extended), anchored to a pre-programmed waypoint and flown automatically via the autopilot (under the full supervision of the pilot).

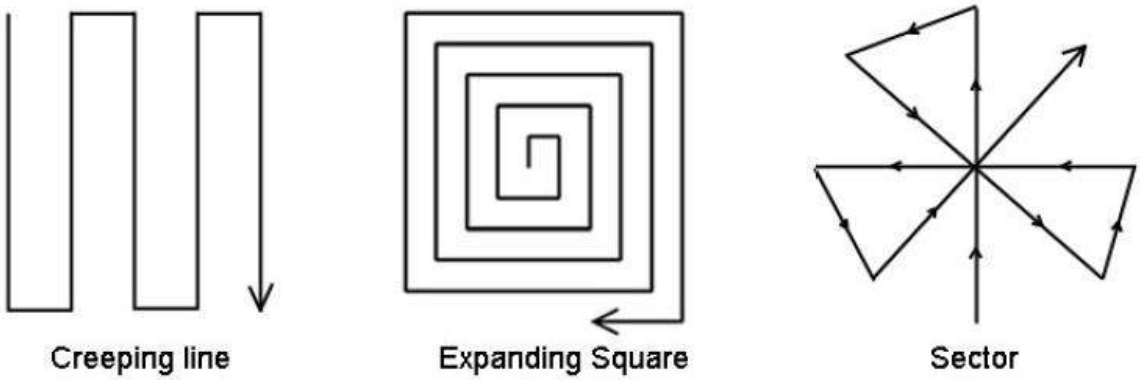

Figure 10 *– example mission profile elements*

In approximately 10% of cases (roughly 10 days per year), we estimate that flight trials will need to be conducted over land (*i.e.* east of the railway line) in order to test specific mission sensors and potential customer applications. These flight profiles will use similar building block elements to those illustrated in Figures 8 to 10, but as discussed previously, the tracks and associated waypoints will be crafted to avoid overflight of buildings, property and any other sensitive areas and will be appropriately geo-fenced. SAC will work with visiting teams to ensure that flight plans respect local sensitivities. In all cases, all flights will also be subject to the CAA granting approval of an Operating Safety Case (OSC).

The Airspace Change is therefore anticipated to have a negligible impact on perceived overflight.

3.4. CO_2 emissions

Ordinarily, CO_2 effects are modelled using the Aviation Environmental Design Tool (AEDT) (based on aircraft movement data), then quantified and monetised using WebTAG outputs. CAP1616 requires the calculation of the total annual (and corresponding change in) mass of fuel burned, and hence CO_2 equivalent (CO_{2e}) emissions, resulting from the airspace change. The AEDT modelling software provides a fuel consumption metric that calculates the mass of fuel burned in metric tonnes. The corresponding mass of CO_2 emitted is estimated by multiplying the mass of fuel burned by a factor of 3.18 to provide a value for the mass of CO_2 emitted for the baseline 'do nothing' option and for each airspace design option. The AEDT model represents an average summer day and the value is therefore multiplied by 365 to provide an annual figure.

For the trials that culminated in the flight shown in Figure 8, the Penguin B drone used approximately 0.35kg of fuel per flight, travelling an average of 17km and with an average flight time of 12 minutes. With regard the the small jet-engined drone shown in Figure 9, the simulation predicts a fuel burn of 6kg to travel 35km in 15 minutes. Assuming approximately 200 novel aerospace system flights per year in total (based on the estimates in Section 2.3), and recognising that up to 50% of these will be flown by zero-carbon electric aircraft, it is obvious that the annual fuel burn is unlikely to exceed 1 tonne and that correspondingly the annual CO_2 emissions are unlikely to exceed 3 tonnes.

To put these figures in context, the annual fuel burn and CO_2 emissions associated with flying activities at Llanbedr as a result of the airspace change will be less than that generated by a single passenger car that travels 10,000 miles a year at 35 miles per gallon.

From Section 2.6 we also know that there will a negligible impact resulting from displacement of other aviation and hence the Airspace Change is therefore anticipated to have a negligible overall impact on CO_2 emissions.

3.5. Impacts on local air quality

CAP1616 requires changes to local air quality impacts to be included in the options appraisal process and that these effects must be conveyed in the consultation materials and quantified and monetised using WebTAG outputs. However, this is normally only required when the proposal affects an area in the vicinity of a location that has been designated as an air quality management area, which is not the case for Llanbedr.

Details on the local approach to air quality can be found on the Gwynedd Council website[21] and monthly data can also be accessed via the Welsh Air Quality Forum website[22].

The Airspace Change is anticipated to have a negligible impact on local air quality.

3.6. Impacts on tranquillity

Tranquillity refers to the remoteness and sense of isolation within the landscape. This is affected and often determined by noise levels and the views and backdrop resulting from an absence of buildings and traffic. Normally, impacts on tranquillity need only be considered with specific reference to Area of Outstanding Natural Beauty (AONB) and National Parks. However, engagement with stakeholders may identify other local sensitive areas for consideration such as heritage sites and popular visitor locations.

The Snowdonia Aerospace Centre sits inside the western coastal boundary of the Snowdonia National Park and borders a Site of Special Scientific Interest, hence the impact on tranquillity of the proposed airspace change is an important consideration. Local stakeholders and agencies such as Snowdonia National Park Authority, Natural Resources Wales, Cadw, and other similar groups, have already been engaged in the earlier stages of the ACP process and will be contacted directly as part of the Stage 3C consultation.

We're confident that the evidence presented with regard to noise (Section 3.2) and overflight (Section 3.3), together with the estimates for limited over-land operation (Section 2.3), will ensure the continued tranquillity of the local environment, but we will continue to engage with stakeholders on a regular basis.

The Airspace Change is anticipated to have a very low / negligible impact on tranquillity.

3.7. Impacts on biodiversity

The majority of airspace change proposals are unlikely to have an impact on biodiversity because they do not involve ground-based infrastructure, but biodiversity factors should still be considered proportionately. Snowdonia Aerospace already has a Wildlife Hazard Management Plan in place and Natural Resource Wales has already been engaged in the earlier stages of the ACP process and will be contacted directly as part of the Stage 3C consultation. In addition, we have commissioned an Ecological Impact Assessment for the site. This survey is intended to provide a baseline assessment of the ecological value and constraints of the site, as well as evaluate the potential impacts of future developments on protected and/or notable species and sites.

The Airspace Change is anticipated to have a negligible impact on biodiversity.

[21] Ref: https://www.gwynedd.llyw.cymru/en/Council/Strategies-and-policies/Environment-and-planning/Air-Quality-Management---Updating-and-Screening-Assessment.aspx
[22] Ref: https://airquality.gov.wales/about-air-quality

3.8. Safety assessment

By definition and design a Danger Area (or Temporary Danger Area) is intended to enhance the safety of aviation operations by creating a small volume of segregated airspace that gives protection to experimental aircraft that are not "able to comply with the current requirements of the Air Navigation Order (ANO), including the Rules of the Air" as per CAA CAP722 Unmanned Aircraft System Operations in UK Airspace – Guidance & Policy.

None of the areas of the proposed DA will be permanently active and will only be activated by Notice to Airmen (NOTAM) when novel aerospace flying activities are due to take place. There is a safety advantage in having a permanent Danger Area as opposed to a Temporary Danger Area as it will be published in standard Aeronautical Information Regulation and Control (AIRAC) documentation as well as being promulgated via NOTAM ahead of activation. Snowdonia Aerospace will work actively with other local airspace users – *e.g.* via the regular RAF Valley Airspace Users Symposium and local Stakeholders where appropriate – to raise awareness of Danger Area activities at Llanbedr.

Once active, the following outline Air Traffic Management principles are expected to apply for both Danger Area Design Options #1 and #2 to ensure safe operation with regard (a) novel aerospace systems remaining within the DA, (b) other air traffic is kept out of the DA, and (c) any transfer between the Llanbedr DA and D201 is managed safely:

- A Flight Information Service (FIS) will be provided by Snowdonia Aerospace from take-off to landing for all novel aerospace operations within the proposed DA. The core FIS will be augmented with an Unmanned Traffic Management (UTM) system with a minimum ADS-B Out monitoring capability. Llanbedr FIS will also provide a Danger Area Activity Information Service (DAAIS) for all airspace users in the vicinity of the DA;
- It is anticipated that the novel aerospace system will be equipped with an ADS-B Out transponder as a minimum electronic conspicuity capability when operating outside of Area A for both Options #1 and #2;
- QinetiQ/MOD Aberporth Air Traffic Control (ATC) will be notified of all novel aerospace operations and their services will be engaged via Letter of Agreement (LOA) for operations that intend to transit through Area D for both Options #1 and #2 to operate in D201 or further into D202;
- The novel aerospace system crew is responsible for monitoring flight systems and communicating directly with Llanbedr FIS or MOD Aberporth ATC;
- In addition, the novel aerospace system crew is to ensure that the aircraft remains within the confines of the segregated airspace during both normal operation and in the event of any routine emergency. The novel aerospace system will be expected to "geo-fence" and maintain a buffer to prevent inadvertent departure from the DA.

With regard unmanned aircraft/drone operations, it should be noted that a Danger Area is only one element of a multi-faceted Operating Safety Case (OSC) that will determine where, when and how a drone can operate and will be subject to review and approval by the CAA before operation within the DA will be allowed.

A permanent DA will also warrant closer attention from the CAA Innovation Hub with regard their "Regulatory Sandbox" activities and is likely to see a case officer nominated to support RDT&E activities at Llanbedr and provide advice to individual operators on an appropriate approach to safety management (independent of the subsequent OSC review).

A permanent Danger Area at Llanbedr is therefore considered to be the most appropriate mechanism to address safety in the face of increasing demand for novel aerospace test and evaluation capability in the UK.

3.9. Impacts on other airspace users

The remaining issues relate to the potential impact on airspace access for the RAF/MOD and other General Aviation operators in the vicinity of Llanbedr Aerodrome. Despite a predicted increase in both novel aerospace RDT&E flying and RAF/MOD training, there is still considered to be sufficient capacity to accommodate all activities safely and the Change Sponsor is committed to implementing Flexible Use of Airspace and Strategic Airspace Management principles (see Section 2.5).

The estimate of approximately 100 days of Danger Area activation at Llanbedr per year translates to 2 days per week and with operations above 2000ft likely only 33% of the time, relative to a base level of 4000ft for Texan T1 and 5000ft for Hawk T2. Similarly, activation of the DA sub-areas creating a corridor to D201 is likely only 33% of the time and engagement with the MOD Danger Area Airspace Manager has identified no fundamental issues other than a need to provide sufficient notice to allow coordination with MOD test activities. Appropriate air traffic management principles have already been identified to ensure spatial and temporal deconfliction across all elements of the Danger Area and a permanent DA will also provide Snowdonia Aerospace with the confidence to invest further in Unmanned Traffic Management (UTM) technology and airspace coverage. On this basis, it is considered that RDT&E flying and RAF/MOD training can safely co-exist (as it did very successfully pre-2004 with much higher numbers of aircraft movements) and that any related operational integration issues could be managed via Letters of Agreement.

Likewise, there is also considered to be more than sufficient capacity to safely accommodate all General Aviation (GA) activities. The current level of GA traffic is only 789 movements per year (2019), averaging roughly 2 movements per day, including weekends, and is unlikely to be unduly impacted by the Danger Area, which will be active an estimated 2 days per week on average, and is less likely to include weekends when GA traffic is more prevalent. Furthermore, DA Option #2 features greater segmentation of the Danger Area that will also allow GA aircraft to safely transit an active DA to the west, east or above (>2000ft) depending on which sub-areas are activated. On this basis, it is believed that RDT&E flying and GA traffic can safely co-exist and that any related operational integration issues could be managed via Letters of Agreement.

3.10. Cost Benefit Analysis

CAP1616 requires that we complete a cost benefit analysis for all related economic impact, however:

1. The economic model for Llanbedr Aerodrome does not conform to that for a conventional airport;
2. The analysis of future airspace use against the six key environmental criteria has shown there is negligible impact to monetise;
3. The sites established planning use, its recognised heritage and its key focus over the past 5 years are all fully accepted by all stakeholders and the local community. In many respects the community and airspace users feel the proposed implementation of a permanent DA will merely revert the airfield to its position previously and this will constitute more of the same and consequently negligible impact.
4. The highly variable nature of the RDT&E market makes a 10-year forecast unrealistic.
5. The Business Plan for Llanbedr Aerodrome relies on a flexible mixed-use model of operations and any investment made in the airfields infrastructure and subsequent operation and deployment costs are spread over the range of mixed uses rather than specific to those only requiring use of the DA.

In light of the specific circumstances associated with Llanbedr Aerodrome it is therefore felt inappropriate to include a specific cost -benefit model along the lines of Table E3 in CAP1616. In particular, DA airspace users do not explicitly derive income from flight operations at Llanbedr, but rather use the test and evaluation capabilities on offer to develop their products and services. It is therefore considered to be more useful to look at the value provided to the wider UK aerospace industry and the derived value back into the local economy.

The primary difference between the "do nothing" option of continuing with a Temporary Danger Area or implementing a permanent Danger Area is that a permanent DA will take away the schedule limitation on RDT&E operations at Llanbedr and provide UK aerospace businesses with a surety of being able to conduct developmental testing in the UK on a reactive basis. There is a growing demand for such a capability, as witnessed by the doubling of activity at Llanbedr over the past two years and the forecast for it to double again in the next two years, particularly to support the upcoming UK Future Flight Challenge. UK Research & Innovation has already highlighted a paucity of aviation innovation or development environments in the UK that will allow real-life demonstration and evaluation of next-generation system-of-system issues as part of its Future Flight Challenge problem statements.

A permanent DA will significantly enhance the UK RDT&E capability in environmentally-friendly aircraft and electric technologies and allow UK Government to move closer to the goal stated in the Aerospace Industrial Strategy, 2018 for "the UK to be at the cutting edge of these exciting developments". The related Aerospace Sector Deal[23] describes the value of the UK aerospace industry as follows:

- *"It provides over 120,000 highly skilled jobs, most of these outside London and the south east. The sector has an annual turnover of £35 billion, the majority of which comes from exports to the rest of the world. This is a world-leading industry, driving growth and prosperity across the UK, supporting jobs that pay 40% above the national average".*

A permanent DA also supports the CAA Airspace Modernisation Strategy (CAP1711) by creating a test zone in which to explore the airspace integration issues associated with new airspace users such as drones that are currently identified as "unknowns" in Chapter 5 of CAP1711.

A commercially-run, civil-focused permanent DA will enable UK business to retain their future flight test programmes within the UK rather than operating abroad, thereby retaining economic activity, jobs and spend in the UK economy.

As well as supporting the development of environmentally-friendly aerospace and aviation in the UK and supporting regeneration of a greener UK economy following Covid-19, there is also a strong local economic benefit to a permanent DA. A recent economic impact assessment[14] suggested a multi-use aerospace site at Llanbedr (with aerodrome licencing, ATZ and DA implementation as fundamental building blocks), if developed in full, could contribute 515 jobs and £19.5m/annum of GVA at the local level and 765 jobs and £34m/annum of additional GVA in Wales over the next 10 years.

3.11. Design Option Preference

The Design Options are intended to reflect (#1) a maximum extent for the DA, and (#2) a maximum segregation/minimum extent for the DA, and additional design options could be generated by combining elements of both options. Multiple such combinations could be identified, but SAC considers the two current options to best represent the distinct alternatives.

As per previous feedback, Option #1 is easier to interpret and provides greater flexibility for operators using the DA, whereas Option #2 is more complex but offers more advantages in terms of flexible use of airspace for other aviation operators (Sections 3.8 and 3.9). The Environmental impact (Sections 3.2 to 3.7) and Economic Impact (Section 3.10) are the same for both.

Both options satisfy the Statement of Need and hence SAC does not feel the need to declare a preference at this point, but rather consider the feedback from a wider group of stakeholders before submitting a final design.

[23] Ref: https://www.gov.uk/government/publications/aerospace-sector-deal/aerospace-sector-deal

3.12. Summary

Taking the analysis in Sections 3.2 to 3.10 together, there is an exceptionally strong argument that implementation of a permanent Danger Area at Llanbedr provides a solution that not only satisfies safety and operational requirements, but also minimises the broader environmental impact, whilst meeting a need that is in the strategic economic interest of both the UK and Welsh governments in terms of accelerating novel aerospace development in the UK and creating jobs in south Gwynedd, respectively.

Given the environmental, safety, operational, and economic considerations presented above, the Change Sponsor strongly recommends that the CAA consider the Llanbedr Danger Area airspace change proposal favourably.

4. Conclusions and Next Steps

4.1. Conclusions

The following conclusions have been drawn for the "Stage 3A Options Appraisal (Phase II – Full)" element of the Snowdonia Aerospace LLP submission for an Airspace Change Proposal, Reference: ACP-2019-58, Llanbedr Danger Area (DA), under the Civil Aviation Authority (CAA) CAP1616 Airspace Change Process:

1. The established use for the Llanbedr site is as an operational airfield and its recognised historic and current / ongoing uses. The site has an existing Certificate of Lawfulness (Ref: NP5/62/LU372) for research and development for testing, evaluation and development of drones and has a current planning consent for a mixed use incorporation, both its established use and for aircraft maintenance, including decommissioning and disassembly, parts recovery, refitting and engineering training (Ref: NP5/62/372A);
2. Snowdonia Aerospace has constructed a model for anticipated Danger Area (DA) utilisation. The number of novel aerospace system flight movements is expected to double, but the numbers are relatively small (~100 days of Danger Area activation per annum and <200 flights per annum), the vast majority of operations (~90%) will be over the aerodrome or out over the sea and the vehicle size (the majority <150kg) and propulsion type (50%+ electric) are also mitigating factors;
3. Using the utilisation model, Snowdonia Aerospace has also assessed the impacts of the permanent DA Design Options #1 and #2 proposed at Stage 2A against a "do nothing" option (continuing under a Temporary Danger Area) using six key environmental criteria in a methodology agreed with the CAA to reflect the unique nature of the RDT&E activities at Llanbedr;
4. The noise profile for an estimated 66% of the novel aerospace systems that will operate at Llanbedr will be below the ambient daytime baseline experienced by local residents and effectively inaudible beyond the airfield boundary. For the remaining 33%, representing about 30 days of operation per year, it is unlikely that noise profiles will be noticeably different from any other conventional fixed-wing general aviation or helicopters that use the airfield. The Airspace Change is therefore anticipated to have a negligible impact on perceived noise;
5. We estimate that only 10% of flight trials cases (roughly 10 days per year) will need to be conducted over land (*i.e.* east of the railway line). The flight tracks will be crafted to avoid overflight of buildings, property and any other sensitive areas and will also be appropriately geo-fenced. The Airspace Change is therefore anticipated to have a negligible impact on perceived overflight;
6. The annual fuel burn and CO2 emissions associated with flying activities at Llanbedr as a result of the airspace change will be less than that generated by a single passenger car that travels 10,000 miles a year at 35 miles per gallon. The Airspace Change is therefore anticipated to have a negligible impact on CO2 emissions;
7. Assessment of local air quality impacts are only required when the proposal affects an area in the vicinity of a location that has been designated as an air quality management area, which is not the case for Llanbedr. Details on the local approach to air quality can be found on the Gwynedd Council website and monthly data can also be accessed via the Welsh Air Quality Forum website;
8. We're confident that the evidence presented with regard to noise and overflight, together with the estimates for limited over land operation, will ensure the continued tranquillity of the local environment, but we will continue to engage with stakeholders on a regular basis;
9. The Airspace Change proposal is anticipated to have a negligible impact on biodiversity because it does not involve change in ground-based infrastructure.

10. Despite a predicted increase in both novel aerospace RDT&E flying and RAF/MOD training, there is still considered to be sufficient capacity to accommodate all activities safely and the Change Sponsor is committed to implementing Flexible Use of Airspace and Strategic Airspace Management principles;
11. The economic model for Llanbedr Aerodrome does not conform to that for a conventional airport, but a recent economic impact assessment suggested a multi-use aerospace site at Llanbedr (with aerodrome licencing, ATZ and DA implementation as fundamental building blocks) could contribute 515 jobs and £19.5m/annum of GVA at the local level and 765 jobs and £34m/annum of additional GVA in Wales over the next 10 years.

4.2. Next steps

The analysis presented here will be taken forward into the public consultation at Stage 3C of the CAP1616 process and will be available for stakeholder review and comment.

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